THE FINDING OF THE REMAINS OF THE FOSSIL SLOTH AT BIG BONE CAVE, TENNESSEE, IN 1896.

By Henry C. Mercer.

(*Read January 15, 1897.*)

The fossil sloth bones found in Big Bone cave, Tennessee, illustrate an investigation at one of the points of contact between paleontology and archæology. They explain an effort made during the last several years by the Department of Archæology and Paleontology of the University of Pennsylvania to settle the question of man's antiquity in North America through a study of the associa-

Fig. 1.—Big Bone cave, at the head of Beech cove, one mile from the left bank of Caney Fork river, and one mile above the mouth of Dry Branch, Van Buren county, Tennessee. On the west slope of the Cumberland table-land, about 1000 feet above the sea. Site of the discovery of the remains of the fossil sloth with attached cartilage.

tion of human with animal remains in caves. Turning away, for a time, from mounds, village sites and buried cities, we have sought

the help of the naturalist[1] in a systematic attempt to penetrate the crust of recent earth under foot, to trace man through a mixture of the familiar vestiges of such animals as the deer, the bison, the bear, the beaver, the muskrat and the wolf, still existing in the American forest, and to follow him down into that older world layer next below called the Pleistocene. There we have endeavored to find, if possible, his bones still associated with the remains of the extinct mastodon, the mammoth, the tapir, the giant beaver and the fossil sloth.

Much remains to be done over a wide territory, before the evidence of American caves, for or against man's geological antiquity, can be adequately collected or reasonably summed up. But already in the territory examined in the eastern United States and Central America, some landmarks seem to have been established in the pre-Columbian darkness.

Here are five vertebræ (three dorsal and two lumbar), a rib, a heel bone (calcaneum), an astragalus, four vertebral plates (epiphyses) and one epiphysis of a humerus, pertaining to an animal whose name and history belong to the records of this Society, since the first remains of the creature ever found in North America were presented here by Thomas Jefferson on March 10, 1797. Struck by the size of its formidable claws then shown, Jefferson[2] gave it the name *Megalonyx* (great claw), afterwards adopted by Cuvier. And I have hunted up at the Academy of Natural Sciences, for comparison with my specimens, this other set of bones, the very ones then exhibited by Jefferson, two of the lower limb (radius and ulna), several of the foot (metacarpal), with a couple of claws, and show them again here one hundred years later, where I wish to note the fact that certain of them have been gnawed, like my specimens, by rodents, though all are heavier than the latter, and much older in appearance.

[1] My grateful thanks are herewith returned to Prof. Cope for his identification of the bones of the extinct sloth here referred to; to Mr. S. N. Rhodes for identification of the hair, quills and refuse of smaller animals; while our study of the layers, and the removal of characteristic portions of the earth in small bags would have signified less if Dr. Harrison Allen had not named for us the bats; Mr. Johnson, of the Wagner Institute, an insect; Prof. Heilprin and Mr. Vaux, specimens of clay and a limestone fossil, and Messrs. Thomas Meehan and Stewardson Brown, of the Academy of Natural Sciences, the remains of plants which one by one came to light at home after the specimen bags were opened and their contents studied in the daylight.

[2] See *Transact. of Am. Philos. Soc.*, 1799, Vol. iv, p. 246.

Found by saltpetre diggers, buried a foot or more below the surface in the floor earth of Cromers' cave, Green Briar county, West Virginia, Jefferson's specimens were apparently only a few of a greater series. Col. John Stewart and a Mr. Hopkins, of New York, saved these here shown. Another bone got to Cuvier in France; the rest were lost. But from that time to this fragments of the skeleton of the gigantic extinct sloth, claws, limbs, a skull or two, teeth and vertebræ, came to light, sometimes in caves, sometimes in alluvial deposits, as the century passed. Several bones were found with mastodon remains mired in the soft saline earth around the springs at Big Bone Lick, Ky.; others in a conglomeration of the bones of extinct animals at Natchez, Miss., where a whole skull was rescued, or in the river alluvium at Memphis, Tenn.; others in White cave, Ky., in Adams county, Miss., and in a cave in northern Alabama, from which a well-preserved series was sent by Mr. Tuomey to the Academy of Natural Sciences in Philadelphia. Southern Louisiana must have been well-colonized by the animals whose remains, together with the bones of the fossil horse and mastodon, are thickly bedded at the bottom of the rock-salt diggings at Petit Anse, where the creatures probably came to lick salt,[1] and the Pennsylvanian forest must have abounded with them from twenty to thirty millenniums ago, judging from the great number of crushed skulls, claws and bones, that I have exhumed from the fossil bone-bearing chasm at Pt. Kennedy along with the sabre-toothed tiger, the mastodon and fossil horse.

Jefferson, with no tooth to judge by, supposed the "great claw," as he called it, to be a kind of lion such as Hawkins, Harriot, Willoughby, Claibourne and other old explorers said they had seen or heard of in the American woods, and he quoted the tales of later Virginian hunters, describing a terrible roaring, and the devouring of a horse, by a great carnivore, which (as in the case of the mammoth) he argued might still exist in the western wilderness then unexplored. But Dr. Caspar Wistar[2] and then Cuvier established the analogy of the Cromers' cave bones with the modern sloth of South America. And when no such living carnivore as Jefferson had fancied was ever found, and when the remains discovered later appeared continually in association with extinct animals, the gigantic sloth soon came to be regarded as a characteristic represen-

[1] Joseph F. Joor, M.D., in *American Naturalist* for April, 1895.

[2] *Proc. Am. Philos. Soc.*, Vol. vi, 526, 1799.]

tative of a category of tapirs, peccaries, horses and mastodons, which had flourished in the time called Pleistocene, at an epoch one geological degree back of the present, or, according to the last of several geological time estimates, about 30,000 years ago.

Here, then, to return to the particular specimens presented by me, (See Figs. 5–14 and 19) are bones which, from the point of view of anthropology, might be presumed to be very ancient, older than the pyramids of Egypt or the oldest inscribed brick yet found in Babylonia, but which, it must be confessed, appear quite modern. I removed them with my own hands out of the floor earth of Big Bone cave, Van Buren county, Tenn., in last May (1896), while conducting thither an expedition for the Department of American and Prehistoric Archæology of the University of Pennsylvania.[1] Strange to say many have articular cartilage clinging to them. Most have been gnawed by small rodents while still retaining their juices, and for these reasons and because, as we shall see later, they form part of a set of bones doubtless of one and the same animal, obtained from Big Bone cave first in 1835, next in 1884, and now last by me in 1896, they may be classed as pertaining to the most modern-looking if not the most interesting series of remains of the extinct animal ever found in the United States. In this case, since the position and the association of the other specimens alluded to of 1835 and 1884, previously found in the same cave by farmers, were not observed, the bones here shown constitute the only remains of this Big Bone cave animal, whose relation to surrounding facts bearing upon their age has been studied so as to furnish some reasonable conclusion as to how and when the creature got into the cave, and whether or not it was a contemporary of the Indian in the Southern mountains.

In the first place, it should be said, that the bones did not come from a human culture layer, nor from a den of large carnivora. Neither were they found at a site where the cave explorer would have chosen to dig, but rather at a spot where all the conditions of exploration seemed unfavorable. They were rescued from one of the subterranean galleries at the last moment after the whole cave had been rifled for saltpetre.

About one mile from the left bank of Caney Fork river, and

[1] I take pleasure in returning the thanks of the Department and of myself to our Vice-President Dr. William Pepper, who alone defrayed the expenses of this expedition.

one mile above the mouth of a confluent called Dry Branch, in Van Buren county, Tenn., probably 1000 feet above the sea, Big Bone cave opens from the carboniferous limestone upon the head of the "Beech cove," one of the secluded ravines called "coves" that furrow the western slope of the Cumberland table land. Though 600 feet, more or less, and a broken reach of country intervened between the cavern and the high cool region above, its general nearness to the plateau[1] and its elevation promised well for the explorer. Subterranean deposits washed away, or disturbed by water, during the supposed invasion of the lower country by post-glacial floods, might well have escaped destruction in a cave lying as high as this, while the chance of unearthing abundant or ancient mammalian remains was increased, if we were to suppose that animals in great numbers had gathered in the vicinity, or that man, if he existed, had sought refuge upon the plateau during a general inundation.

But the configuration of the cave, at its entrance, disappointed us. By all past experience, the gloomy hole (see Fig. 1) overshadowed with large "tulip trees" was too wet and steep for savage shelter. Water dripped from the low arch forty-two feet wide and only six feet high. The down-washing of rain from the hill above had choked the vault with loose stones, and disturbed any deposit of earth that may ever have existed within sight of the outer world. Just where we had expected to discover evidence of value, at the point where caves are usually richest in significant remains, there was no work for shovel and pickaxe. To our surprise, the point of interest in Big Bone cave lay far beyond the reach of daylight. It

[1] The Cumberland table-land, a flat-topped continuation of the Alleghenies with sandstone top set on limestone base, extending from northeast to southwest across the entire State of Tennessee, comprises, according to Prof. Safford, 5100 square miles, or one-eighth of the State. Rising 1000 feet above the valley of Tennessee and 2000 feet above the sea, its eastern edge forms a generally straight line, while its western escarpment is notched and scalloped by deep "coves" and valleys, where erosion has laid bare the underlying stratum of "mountain" (carboniferous) limestone upon which the plateau is founded. At almost all points on both sides, the surface suddenly breaks off in sandstone bluffs or cliffs from twenty to two hundred feet in height, giving generally a sharp and prominent margin or brow to the plateau. The carboniferous sandstone surface of the high region, overspread with a sandy, coarse and sterile soil, is often flat for miles. Then again it is rolling and diversified with hills and shallow valleys. In the northeastern part there are high ridges containing many beds of coal, which may be regarded as mountains on a table-land. See *Elementary Geology of Tennessee*, by J. M. Safford, Nashville, p. 32.

was only found after turning to the right from the main tunnel and following a small bifurcating passage for 900 feet.

As we groped onward, the cave became dry, and the candles revealed a line of clay stains waist high upon the narrow walls, marking the limit of nitrous earth previously excavated along the entire length of the gallery. Without the superfluous assertions of our guide, James Priest, and the land owner, Mr. G. B. Johnson, we might have inferred that we had entered one of the numerous Appalachian caves, where the floor accumulations, because they contained saltpetre, had been removed by gunpowder makers at times of need in the wars of 1776, 1812 or 1863.[1]

Laden with pickaxe and shovels, baskets, instruments, candles and provisions, now crouching where the roof lowered, now clambering upon a log across an intersecting crevice, eight or nine feet deep, we followed the lead of Priest, until directly on the footway a spot was reached where, in the utter darkness, beyond the range of the continued haltings of men, and probably of large animals, at a point where no human culture layer, under ordinary circumstances, could have been formed, these remarkable bones of the sloth and all other sloth bones, known to have been previously removed from the cave, were found. Elsewhere the evidence of the relation of animals and men to the cavern, whatever its character, had been destroyed.

[1] Judging by the wall stains, from one to three feet of this floor earth had been removed throughout the nine hundred feet of the passage observed, and the large pile of leached earth, just under the entering arch of the cave, the still greater rampart outside and several similar heaps at other points in the neighborhood, where water for leaching was convenient, testified that the numerous "petre diggers" of the war of 1812 (about three hundred in number, said Mr. Johnson) and their successors of the Rebellion, had done a formidable amount of work underground. Many thousands of sacks, full of the pungent earth, had been carried upon their backs by way of devious passages, with many tedious twists and leanings, crawls and squirms from the eternal darkness to daylight. To leach the earth you place it (according to Mr. Johnson) in a wooden funnel-shaped hopper, with a drip orifice at the bottom. After pouring on water, an equal mass of which the dry earth absorbs, the hopper at length begins to drip and continues to drain off a pungent liquid caught in a vat. Having "seeped" for several days, the drops loose their taste, proving that the earth has lost its strength, or is, in other words, leached. Then the treatment of the liquor begins. This is poured through a similar hopper full of wood ashes and drips not, as before, clear, but now darkened with impregnated lye. Boiled down after this to half its volume in kettles, the liquor thickens, and, when allowed to cool, at once hardens throughout suddenly into beautiful cyrstals of pure saltpetre, when it is ready for sale. Such is the process familiar to the memory of many of the wild-looking mountain men, whose subterranean labor, unfortunately for archæology, has destroyed the interesting evidence once furnished by many of the cave floors in eastern Tennessee.

The record of these bones is, therefore, very different from that of animal remains dug out of the rock shelters of Europe, or from that of specimens derived from any layer of caked human rubbish where savages have been wont to take subterranean refuge. Men certainly did not bring them into the cave. Frost had never reached them. Neither would change of temperature have affected them where they appeared to have rested in the dry earth in an unchangeably cool air since the time of their deposition.

Let us describe this place. The roof has expanded over several branching alcoves, partitioned head high by screens of eroded rock. Mysterious crevices in the ceiling rise above us beyond the reach of candle light. There are no stalactites and we feel no trace of dampness. The severe outside heat of the Southern spring has been reduced to a dry and cool subterranean temperature of fifty-five degrees Fahrenheit. Where a flanking screen narrows the gallery to a width of three and four feet, the earth is soft and mealy under foot and covers the whole floor, rising in a cloud of dust when disturbed by a kick. This floor deposit proves on examination to consist of a noxious and volatile mantle of dry, loose excrements, mixed with vegetable remains, covering up and spoiling by its intermixture the nitrous earth resting in lumps beneath it, and thus sufficiently explaining why, as far as saltpetre digging was concerned, that part of the cave had never been disturbed.

To further examine this floor, later to search the surrounding alcoves, and to discover upon several ledges shoulder high a series of ancient water-made holes, large as stove-pipes, down which nuts, leaves, grass and dung had slid, was to explain the existence of the rubbish at that point. The spot had long been and probably was still a den of busy cave rats, who with porcupines, reaching the gallery not by the outer cave entrance but by the air holes described, had brought thither their vegetable food and trophies from the outer world. Though none of the conspicuous nests of dry grasses and moss loosely interwoven, such as I had previously observed lying on the floor of a rat cave on the New river in Virginia, were seen, several wads of moss, found later in the rubbish, seemed to indicate that the *Neotoma magister* had nested there at some time before the visitation of the cavern by saltpetre diggers. Once again let us say that we were directly upon the cave path, where back and forth over the dusty manure all footsteps of all saltpetre hunters, all white men, all Indians, choosing to penetrate deeper into the

cave, must needs have passed. Their trampling had draggled the surface, kicking earth into it from other areas, or dropping "petre dirt" upon it from bags. Moreover charred pieces of resinous pine, *Pinus mitis;* twigs of hazel, *Corylus americana*, and fragments of burnt cane, *Arundinaria tecta*, strewed the surface, representing doubtless the remains of the torches of such white nitre hunters as had not had lamps or candles, and, we may reasonably suppose, of the Indians who had preceded them (see Fig. 2). The appearance of this surface film then, which I have called

LAYER I

(2 to 3 inches thick),

thus disturbed for two or three inches, and scattered with lumps of nitrous earth and with these burnt sticks, was sufficient to demonstrate that human beings had visited the cave if no further proof of the fact had existed. Over and above the certainty that white men had long passed and repassed the spot, and that many of the torch ends, and particularly the pieces of pitch pine (which suggested the splitting agency of iron tools), might be referred to them, it seemed reasonable to suppose that some at least of the pieces of charred cane (resembling fragments of *Arundinaria* found by us mingled with aboriginal bones in the sepulchral chasm at Lookout cave) had been cast away at the spot by Indians.

Our party of four, Mr. G. B. Johnson, James Priest, my assistant, Joseph Mussleman, and myself, had stopped, and Priest, our guide, holding down his candle, pointed to a hollow caused by digging in the mass of dry manure, where he about 1884, while filling several bags full of the "fertilizer," as he called it, for his garden, and later Mr. Johnson himself on a similar errand, had found several vertebræ, ribs, the pelvis and the skull with teeth of a large animal (the extinct sloth), which, after remaining for some time at the house of Mr. Johnson, had been sent to Nashville and sold.[1] For this reason, and as well testified by the letters to me of Prof. J. M. Safford, State Geologist of Tennessee, who first advised my exploring the cave, let it be said in parenthesis that without doubt the sloth skull now in the possession of Prof. Safford, at Nashville, and which I have been unfortunately unable to obtain from him for comparative study, is the skull thus found by Priest,

[1] By a Mr. A. J. Denton, as Mr. Johnson informed me.

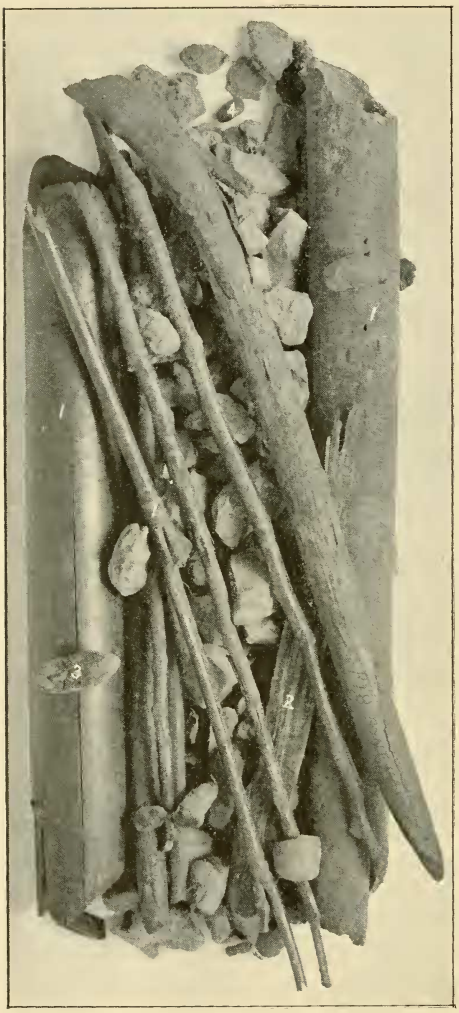

FIG. 2 (x ½).—Specimens of the cave rubbish, fragments of cave clay and coprolites; 3, of porcupine, *Erethizon dorsatus;* 4, of cave rat, *Neotoma magister*, and the cast-away ends of torches resting on the surface of the cave floor (Layer 1), above the spot where the sloth bones were unearthed; 1, *Arundinaria tecta*; 2, charred splinters of pitch pine, *Pinus mitis*, and seven charred twigs of hazel, *Corylus americana.*

and because this skull and the other bones belonging to Prof. Safford, corresponding to those described as found by Priest and Johnson at this place also show cartilage, and further because the evidence indicates that there was only one sloth at this point, with no reason shown why there should have been more than one, and because it appeared that no other spot adapted for the discovery of fossil bones had existed at the entrance of the cave, for these reasons, I believe that the Nashville bones and my set go together as parts of one animal; and further, as first suggested by Prof. Safford and now shown by my examination, let me add that still another and a third set of sloth bones, belonging to the Academy of Natural Sciences of Philadelphia, herewith shown (see Fig. 3 for one of them), found by a farmer in the cave and described by Dr. Harlan in 1835, also showing cartilage

FIG. 3 (actual size).—Claw with cartilage and horny sheath of the sloth Megalonyx, from the J. P. Wetherill collection at the Academy of Natural Sciences of Philadelphia. One of the bones found in Big Bone cave before 1835, and inferentially a part of the same young animal represented by the other illustrations. Red cartilage sticks to the articulation. An *undecomposed* horny sheath covers almost the entire bone. (Photographed by kind permission of Dr. S. G. Dixon.)

equally fresh in appearance and referable to a young animal (because of the loose epiphyses) may well be believed to constitute skeletal portions of the same individual.[1]

These subsequently arrived at conclusions, however, did not concern us when first pausing in the candle light, we placed our tools and baskets upon the ground to listen to the account of Priest. Our hope of finding more bones depended upon the chance that he had not dug up the whole floor and that other remains, resting beyond the limit of his digging, had escaped him and remained to reward our search.

Down through the manure and nitrous earth resting beneath it, from nine in the morning till five in the afternoon, beginning where the consistency of the deposit showed that Priest and other diggers had left off, we worked in the dim candle light, until our hunting had accomplished its object, and until the walls of our trench revealed the facts herewith described, and first that of a sequence in time marked by the layers that had accumulated upon the foothold, and of which two epoch-denoting divisions confronted us. They consisted of (below and older) a water-deposited nitrous clay, resting upon the bottom rock, standing for a time when the cave was wet, and (above and later) the manure previously referred to, testifying to an epoch when the cave was dry, and to the latter division with its subdivisions described as Layers 1, 2 and

[1] Dr. Richard Harlan (see *Medical and Physical Researches*, by Richard Harlan, Philadelphia, 1835, p. 321) describes the set at the Academy of Natural Sciences in 1835. He speaks of and partially figures "two claws of the fore feet, a radius, a humerus, a scapula, one rib and several remnants, an os calcis, a tibia, a portion of the femur, one lumbar and four dorsal vertebræ, the portion of a molar tooth, together with several epiphyses, the bones of a young animal imperfectly formed at the extremities." Distinctly noting the cartilage on several of the specimens, he calls particular attention to the nail on one claw (see Fig. 3). According to him, they were obtained by Mr. Dorfeuille (proprietor of the Cincinnati Musem) from a Mr. Clifford of Kentucky, bought from Dorfeuille by Mr. J. Price Wetherill, and presented by the latter to the Academy of Natural Sciences. Harlan had in another paper referred to these bones as coming from White cave, Kentucky, and after repeating the statement here corrects it at the last moment with a footnote which says, "According to the recent observations of Dr. Troost, these bones were derived from the Big Bone cave, Tennessee." My guides' Priest and Johnson had heard of the discovery of other sloth bones at the cave in the early part of the century, and for the reasons above given I have no doubt that the nitre diggers (of 1812 probably) found them at the site of the other discoveries, and that Clifford obtained them through intermediaries. Interesting details of this first discovery would probably appear in Dr. Troost's communication to Dr. Harlan if it could be found.

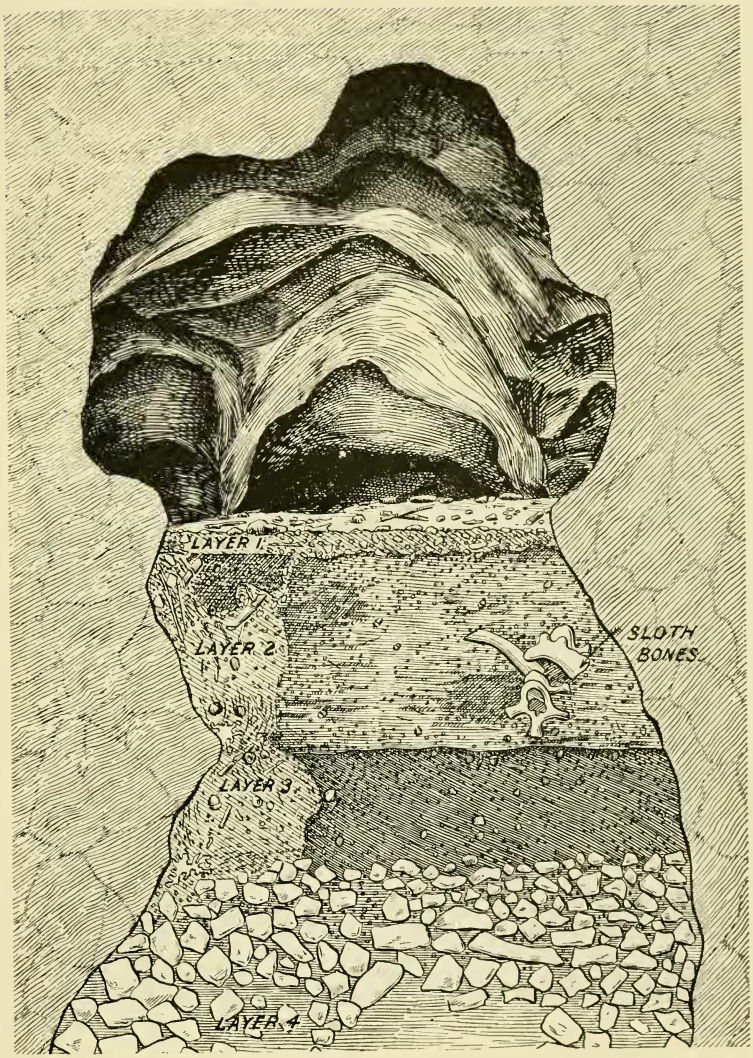

FIG. 4.—Diagram showing a vertical section of the gallery in Big Bone cave where the sloth bones were found. Layer 1 (2–3 inches), disturbed surface rubbish with charred torch ends. Layer 2 (2 to 2½ feet), dry loose rat excrement, animal and vegetable remains, etc., with sloth bones. Layer 3 (1 foot), crusted lower portion of rat excrement and vegetable remains formed before the advent of the sloth bones. Layer 4 (of undetermined depth), loose pieces of nitrous clay, dry and hard, mixed with manure. The disturbance resulting in the intrusion of torch ends and other objects into the deposit as far as Layer 4, caused by burrowing rats, is seen against the left cave wall.

3, and hence to the later time belong the sloth bones here shown. One after another they were found in the dry manure, which, lying invariably under Layer 1 above described, I have called

LAYER 2.

(*2 to 2½ feet thick. See Fig.* 4.)

As we worked forward through this layer with shovel, hands and trowel to where it thinned out and the saltpetre earth now removed had formed the foothold beyond it, we found it to consist almost entirely of well-preserved, dry excrements of the cave rat, *Neotoma magister*, which, intermixed in lesser quantity with coprolites of porcupines, *Erethizon dorsatus*, formed the conspicuous ingredients of the mass. In consistency like a bin

FIG. 5 (x ½).—First bone found (in Layer 2, depth about 18 inches), epiphysis or unknitted end of the humerus of a young sloth, Megalonyx. Photographed, resting upon the characteristic rubbish of Layer 2 found around it. 1. Bat's jaw, *Adelonycteris fusca*. 2. Hickory nut and fragment gnawed by rodent, *Hicoria glabra*. 3. Excrement of large mammal, possibly sloth. 4. Felted hair of bats, rats and porcupines mixed with a woolly fur, possibly belonging to the sloth itself. 5. Bones of the bat, *Adelonycteris fusca*. The background is composed of a mass of dry coprolites of cave rats, brown dusty earth, and fragments of hard cave clay, "petre dirt."

of oats, the deposit answered every disturbance with a cloud of pungent dust. Nuts, sticks, fur and moss were easily seen in it by candle light, but more minute search in the cave and a subsequent study of the specimens preserved, revealed at various points, the seeds, grass, bark, leaves, hair and small botanical fragments described later. In the midst of this interesting rubbish, often in contact with seeds, nuts and hair, appeared the twelve sloth bones here shown, protruding from the vertical side of the trench at depths of from eight to fourteen inches.

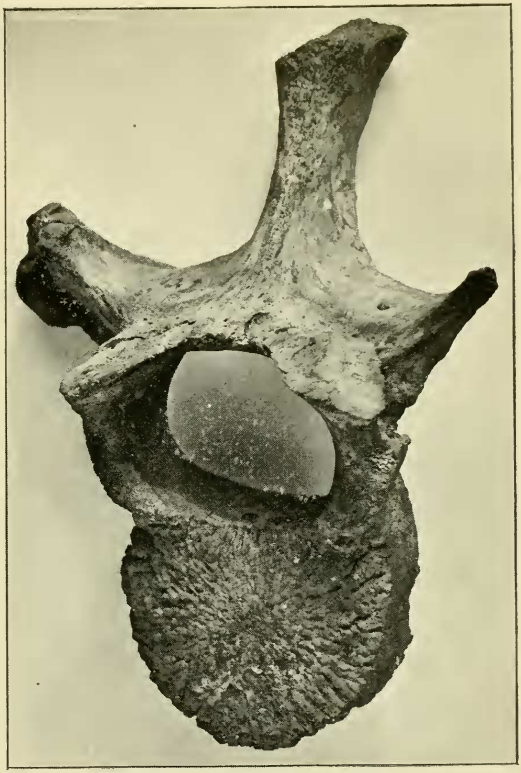

FIG. 6 (x ½).—The second bone found (in Layer 2, depth 1 foot 8 inches). Dorsal vertebra. A minute fragment of attached cartilage is not visible in the photograph. The marks of gnawing are upon the opposite side of the specimen.

No fear of breaking them, hard, dry and strong as they were, and I question whether they needed the dose of hardening solution which all but four of them have since received, and which has somewhat discolored them. In the dusty dimness we saw the cartilage, marked the signs of rodent gnawing,[1] and numbered each bone with India ink as it came out.

[1] The bone gnawing of rodents, done with their incisor teeth, often characteristic of bones found by me in American caves, differs greatly from the traces of mastication of the larger carnivoras. The latter, as dogs for instance, working sideways with

The first bone found (See Fig. 5) was an epiphysis of a humerus. Then came a well-preserved vertebra No. 2 (see Fig. 6), found at a depth of one foot eight inches below the surface and one foot from the right wall of the cave. The small coprolites touched it on all sides. Just above it lay a small twig of wood, and close to it several bones of bats, described later, while both above and below it we noticed wads of fine hair. The deposit was exceedingly dry, and its removal filled the cave with suffocating dust clouds. Immediately in contact with bone No. 2, as we worked horizontally into the bank, lay bones Nos. 3, 3½ and 4, two unseparated vertebræ with a loose epiphysis resting between them (see Figs. 7 and 8), directly under which we found two gnawed hickory nuts and an acorn.

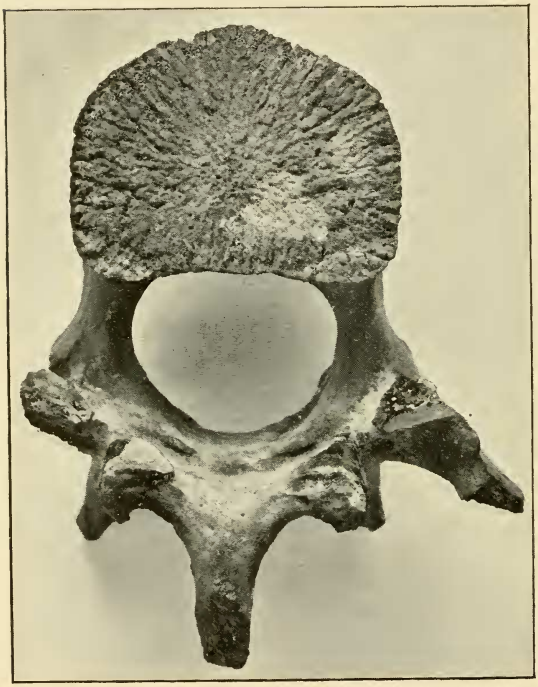

FIG. 7 (x ½).—Third bone found (in Layer 2, depth 20 inches). Dorsal vertebra. Signs of rodent gnawing not shown in photograph. Cartilage is seen attached to the base of the right projection.

As we advanced vertically into the manure, another vertebra, the fifth bone found (see Fig. 9), bone No. 6, the heel bone (calcaneum) (see Fig. 10), and bone No. 7 (the astragalus), (see Fig. 11), were revealed lying but a few inches apart. With deep interest I removed them. Just below the fifth bone, at which point the

their sharp canines and edged molars, dent the bones, or tear their corners irregularly, while the rodents furrow the points of vantage neatly, with numerous unmistakable parallel grooves, resembling the work of a coarse file held evenly.

deposit had hardened considerably (Layer 3) and was mixed with fine pieces of saltpetre earth, another acorn was found, and still another under the astragalus.

On that day, May 6, 1896, at 3.15 in the afternoon, with the wind blowing from the north, a slight draught of air wafted the currents of dust inward as we worked, while, to testify to the open communication of that part of the gallery and the outer world by means of the roof holes, a small cricket appeared, crawling upon the disturbed earth as we worked at the third bone.

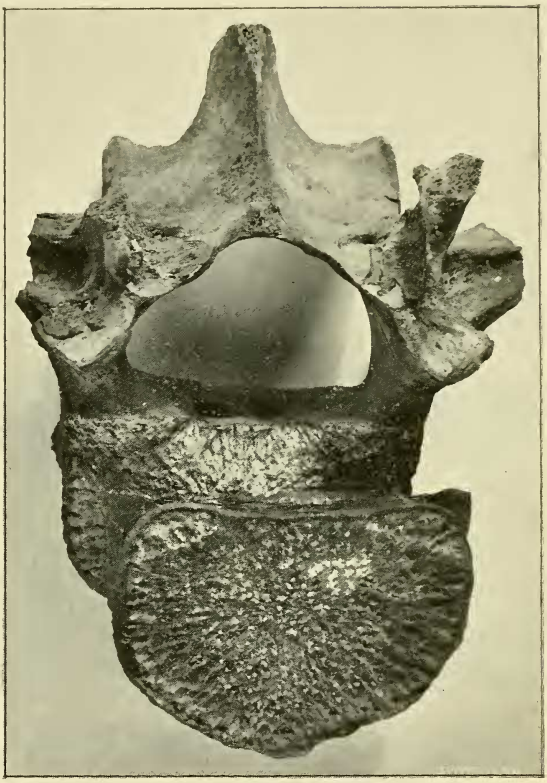

FIG. 8 (x ½).—The fourth bone found (in Layer 2, depth 20 inches). Dorsal vertebra and its loose epiphysis (unknitted plate), illustrating, because not yet ossified together, the undeveloped backbone of a young animal. The photograph fails show the signs of rodent gnawing and the bits of cartilage attached to the bone below the orifice.

A considerably gnawed rib fragment, (see Fig. 17), was followed by a loose epiphysis (see Figs. 12 and 13) and a final vertebra, the tenth bone found (see Fig. 14), lay against the rock wall on the right, not much more than eight inches below the surface, where, close to the top of the deposit and still against the wall, the wads of hair were best preserved. Here also

were found a gnawed butternut, several pieces of grass, several small bat bones and dung as usual. The position of these latter objects close to the wall caused us to suspect that they had slid down from the surface, just as close to the left side twigs of leaves had probably been intruded in the rat holes. But the objects found at or below the position of the other bones we regarded as of equal age with them, and as truly indicative of the nature of the layer.

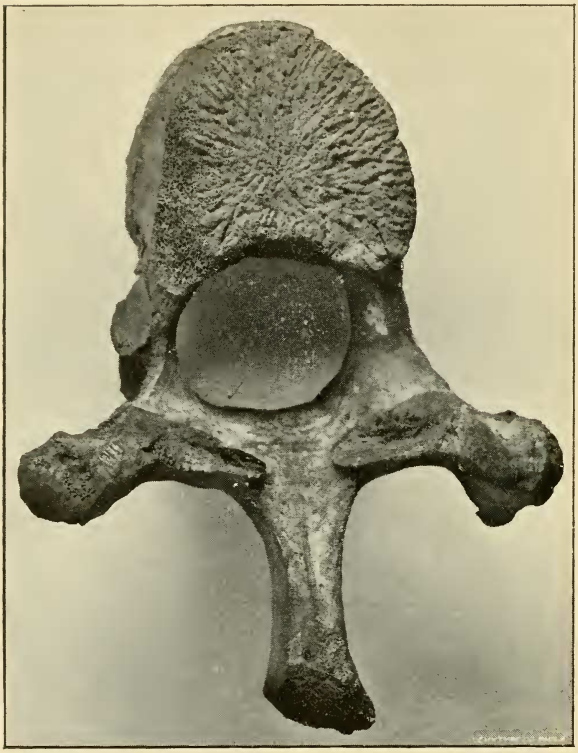

FIG. 9 (x ½).—The fifth bone found (in Layer 2, depth about 14 inches). Dorsal vertebra. The signs of rodents gnawing, clearly visible in the original, show faintly on the left projection. The cartilage shows indistinctly in the illustration on the upper surface of the left circular plate below the large orifice.

Our observation of the position of all the bones showed that they were not (with the exception of the two vertebræ and epiphysis (Figs. 7 and 8) in skeletal order: several epiphyses were loose; the calcaneum (heel bone) lay close to the vertebræ; the single rib found was broken and turned. Unquestionably the bones had been dragged and twisted out of place (inferentially by the gnawing rats or the porcupines) since their deposition. Some

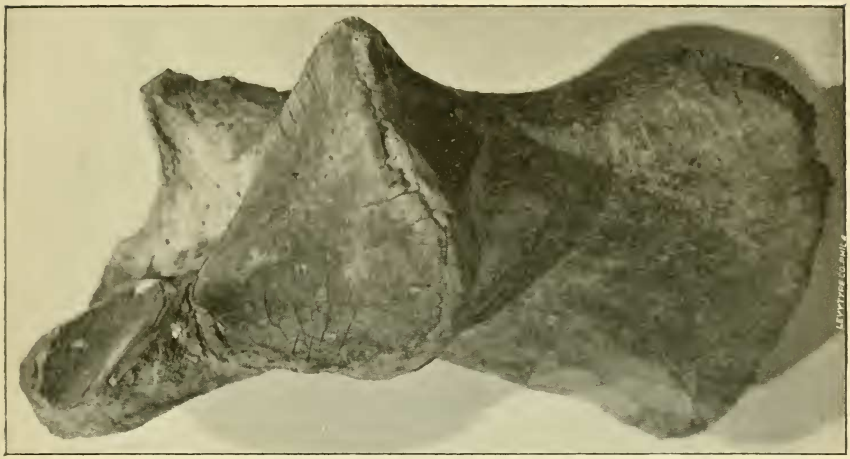

FIG. 10 (x ⅔).—The sixth bone found (in Layer 2, depth about 1 foot). Calcaneum (heel bone) of the extinct sloth Megalonyx. The cartilage (of a bright red toning into yellow in the original) rests as a thick film, considerably cracked, on the left articular face. Marks of rodent gnawing are shown around the lower circumference.

FIG. 11 (x ⅔).—The seventh bone found (in Layer 2, depth about 1 foot). An astragalus (joint or hinge bone of foot). A layer of cartilage (yellowish red in the original) covers the round face and protrudes in brittle flakes from the hollow.

FIG. 12 (x ⅔).—The ninth bone found (in Layer 2, depth about 1 foot). Two vertebral epiphyses indicating, because unwelded upon the larger bone, a young animal. The cartilage is plainly seen above the break.

FIG. 13 (x ⅔).—The ninth bone found (in Layer 2, depth about 1 foot). Fragment of the vertebral epiphysis shown in Fig. 12. The attached cartilage is plainly seen. The color of the latter in the original is semi-translucent red.

may have been carried away to hidden crannies through burrows noted later communicating with the rubbish.

Long before we had pulled the last bone out of the dust, our attention was attracted to the lower or older portion of the manure, which, owing to its peculiar consistency, I have called

LAYER 3.
(*1 foot thick.*)

In it we observed no porcupine quills or tufts of fur, and for the reason below stated suspected that this lower subdivision of the dry ex-

crement had become hardened and caked together just under the bones, into what it seemed reasonable to suppose had constituted the foothold of the cavern when the extinct animal appeared. Objects found in it, therefore, a further series of nuts, seeds, twigs, leaves, bat jaws, and fur described below, together with the dry carcass of the window fly, were to be reasonably regarded as older than the sloth.

How may we better account for the character and position of this crust, than by supposing that it represented that portion of the once lower floor where the carcass of the animal had for a time rested and into which the juices had filtered, caking together the coprolites during the consumption of the flesh by rats and porcupines?

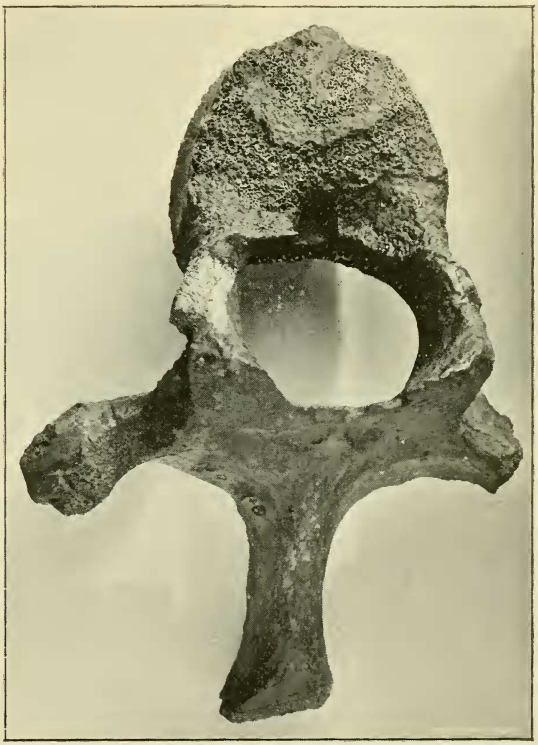

FIG. 14 (x ½).—The tenth bone found (in Layer 2, depth about 8 inches). Dorsal vertebra more wasted than most of the other specimens. Discolored by a preservative preparation applied since its excavation. The signs of rodent gnawing are not shown in the photograph.

This not improbable suspicion was strengthened when we considered the number of bones found at the spot, not simply the twelve exhumed by us, but those previously excavated by Priest and Johnson, now in Prof. Safford's possession, and we may add the eighteen other remarkable cartilaginous specimens, presumably from the same spot, at the

Academy of Natural Sciences. If the whole combined series fails to duplicate or contradict the construction of a single fossil sloth skeleton, then all, because all indicate a young animal, and because all show cartilage as no other sloth bones elsewhere found have yet done, can be reasonably referred to the same individual animal. Many other bones, originally near or upon the surface, may have been removed by Indians or carried away by saltpetre diggers and lost. Rats may have made off with others. And, notwithstanding the fact that the sets belonging to the Academy and Prof. Safford, together with my specimens, may fail to reconstruct the animal's skeleton, the three sets together include enough bones to indicate that the creature had once lain there in the flesh. Because the tooth marks seem to refer to the work never of carnivora, but always of rodents, less to the efforts of large than of small animals not strong enough to have carried a skull such as Priest found, or a scapula like that at the Academy, from any other resting place in the cave, it seems reasonable to suppose that the bones reached their position by the most natural of agencies: that the sloth, lost or overcome by sickness in the darkness, had lain down to die at the place in question.

Reasonably doubting that it had shambled into the cave after the helpless club-footed manner of the modern Ai or Unau, shall we speculate further and imagine that the animal, less clumsy and sluggish than its modern South American relatives and presumably herbivorous from the structure of its teeth, was attracted to the spot by the smell of grass and leaves, brought thither by porcupines and rats? If not, we must believe that its choice of a deathbed in the only rat den in that part of the cave was a coincidence. But, however the position of the bones is to be accounted for, let us believe that if the carcass lay upon the manure, the number of visiting omnivorous rodents increased until the process of devouring the flesh had been succeeded by the gnawing of the bones.

If these suggestions explain how the bones came to be where we found them, we next ask, How old are they? When did they reach their position? An inquiry above all depending upon the study of the objects dug out of the earth with them. These are to be divided into three classes: First, *objects of later age than the bones, or of doubtful antiquity;* second, *objects as old as the bones,* and third, *objects older than the bones.* To the first class belong the torch ends of cane,

Arundinaria tecta, hazel; fragments of clay, coprolites, and bits of charcoal, mentioned above, as belonging to Layer 1, and, second, objects artificially intruded into Layer 2.

Objects of Later Age Than the Bones, or of Doubtful Antiquity.

The hoarding habit of the underground rat had helped our investigation at Big Bone cave, but his burrowing perplexed and vexed us, confronting us with one of the dangers that often threaten exact observation in caves. The slowly formed accumulation of dry excrement had been undermined and disturbed by the tunneling of its makers against the right and left walls, where several rat holes were revealed by a variation in the texture of the neighboring layer. Pushed and wadded into these burrows (see Fig. 15) we

Fig. 15 (x ½).—Specimens of displaced rubbish found stuffed into and filling the rat holes. 1, 2 and 3. Burnt sticks, pieces of charred cane, *Arundinaria tecta*, and charred hazel twig, *Corylus americana*, representing the ends of burnt-out torches cast away by white men or Indians, often found at a greater depth in the layer than the sloth bones, having been intruded into the burrows from the surface by small animals.

found a bunch of moss, *Hypnum;* ten twigs from three to eight inches long, charred at the ends and evidently the remnants of torches, used by Indians or white men, of the hazel, *Corylus americana;* five fragments, one of them charred and three inches long, of resinous yellow pine, *Pinus mitis;* a fragment of charred cane stalk, *Arundinaria macrosperma*, and another twig about eight inches long, not burned, of the cane, *Arundinaria tecta;* a gnawed pig nut, *Hicoria glabra*, and a shellbark, *Hicoria ovata;* a piece of hickory nut, *Hicoria minima;* a chokecherry stone, *Prunus virginiana* Linn.; a piece of hazel nut, *Corylus americana;* a fragment of an acorn of the pin oak, *Quercus palustris*, and three pieces of winged seeds of the blue ash, *Fraxinus quadrangulata*, besides a piece of bark, probably hazel, and fragments of unidentified grass and bark. Besides these botanical specimens kindly identified (with all others referred to in this paper) by Mr. Stewardson Brown, of the Academy of Natural Sciences of Philadelphia, Mr. S. N. Rhoads, and Dr. Harrison Allen, of the Academy, have further settled the identity of twenty quills of the porcupine, *Erethizon dorsatus*, with its numerous excrements, (See Fig. 16) and a piece of hair, which had found their way into the holes, besides the upper jaw with portions of the skull of a bat, *Vespertilio gryphus;* and a lower and upper jaw, with teeth and cartilage attached, of a larger bat, *Adelonycteris fusca.* More excrements of porcupine seemed to have worked into the choked-up holes than were observed in the undisturbed portion of the layer, while with them was found a fragment of the brain case of a large mammal, smaller, according to Mr. Rhoads, than an adult bear. If this small specimen, not an inch in length, cannot be regarded as a portion of the remains of the Megalonyx, it represents the only trace of any

FIG. 16 (actual size).—Quills of the porcupine, *Erethizon dorsatus*, found with other intruded rubbish at various depths in the rat holes. No signs of the porcupine were found in the lower part of the manure (called Layer 3). Coprolites of cave rats and pieces of clay form the background.

other large animal that we, or our guides previously, were able to find at the spot. But the objects found in the rat holes could not reasonably be associated with the bones. Though positively testifying to the presence of men as well as of animals in the cave, the charred torch sticks and other articles had been transported from their original position in the manure; and while it was certain that objects found in the superficial Layer 1 (including the torch ends, see Fig. 2), were more modern than the sloth bones, the rat-hole specimens had lost their true time relation to the sloth. If not all intruded downward from above, and so presumably more modern than the bones, the collective age of all the specimens was doubtful and offered no evidence of the contemporaneity of man and the Megalonyx.

On the other hand, no sign of disturbance was presented by the texture or contents of the middle portion of Layer 2. There the objects found at various points, and particularly close to the bones, seemed fairly to be regarded as ingredients of the deposit. Undoubtedly they represented plants and animals in existence at the time the bones had been deposited.

As we dug on with shovel, hands and trowels, narrowly observing that part of the manure (in many cases preserved by us in bags) lying in immediate contact with the bones, our work revealed by reasonable inference a series of

Objects as Old as the Bones.

In the handfuls of refuse removed from close proximity to the sloth bones and preserved in bags were found, as identified by Mr. Rhoads (see Fig. 23), numerous tufts of the fur (also found in the rat holes), a comparatively large excrement quite unlike the other coprolites in size and shape, attributed by Mr. Rhoads to an herbivorous animal (see Fig. 17 object 8 and Fig. 5 object 3). Of the common coprolites previously mentioned, the larger and scarcer ones containing fine shining particles of undigested hulls and skins of nuts, showed that the porcupine (*Erethizon dorsatus*), guided by other senses than sight, had been continually present during the formation of Layer 2. So testified a hair from the back of one of these animals (Fig. 17 object 16).

Eight beautifully preserved minute jaws and several little bones were identified by Dr. Harrison Allen as the remains of two kinds of still existing bats, *Adelonycteris fusca* (see Fig. 17 objects 17)

and the smaller *Vespertilio gryphus*. Unfossilized and fresh look-

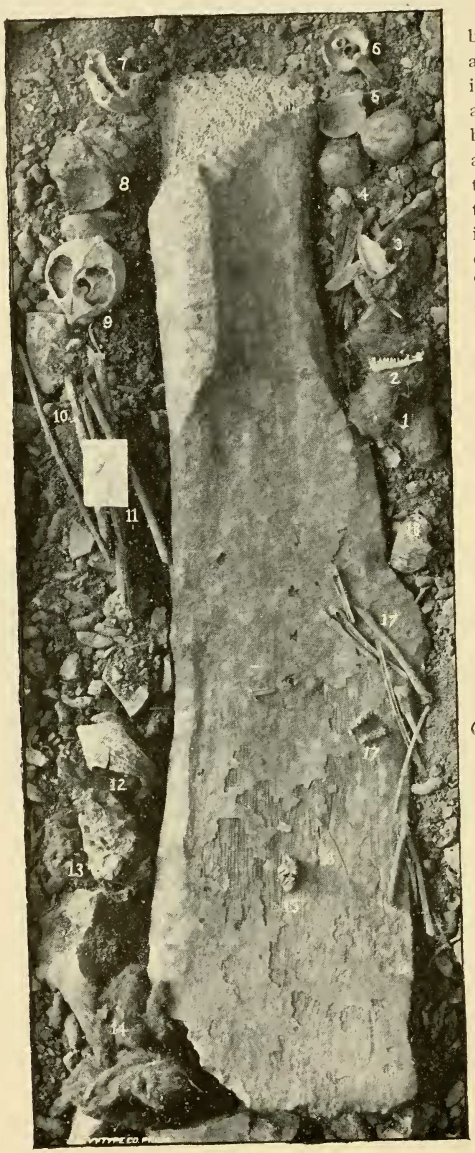

FIG. 17 (x ½). — Eighth bone found (Layer 2, depth about one foot). A rib showing signs of rodent gnawing along its edges. A part has been broken off at either end, and the specimen appears to have been much dragged through the refuse. Its color is light brownish yellow. No cartilage was attached to it. The rubbish of Layer 2 forms the background. Noticeable ingredients of the layer are ranged on either side of the bone. 1 and 14. A felted mixture of rodent hair with woolly fur, possibly of sloth. 2. Bat jaw, *Adelonycteris fusca*. 3. Beech nut, *Fagus americana*. 4. Winged seeds of blue ash, *Fraxinus quadrangulata*. 5. Acorns of red oak, *Quercus rubra*. 6. Acorn cup of Spanish oak, *Quercus digitata*, sunflower, *Helianthus annuus* and alder, *Alnus incana*, seeds. 7. Hickory nuts, *Hicoria minima*. 8. Coprolite of large animal, possibly Megalonyx. 9. Gnawed shellbark, *Hicoria ovata*. 10. Twigs. 11. Fragments of skein of maize silk, *Zea maiz*, excluded from the evidence for reasons given in the footnote to page 63. 12. Gnawed hickory nut. 13. Another coprolite of large animal. 15. Jaw with teeth of cave rat, *Neotoma magister*. 16. Porcupine hair, *Erethizon dorsatus*. 17. Bat jaw and bones, *Adelonycteris fusca*, with twigs of dogwood, *Cornus alternifolia*, just below. 18. Hazel nut, *Corylus americana*.

ing, the bones, according to Dr. Allen, represent individuals which

had fluttered through the congenial blackness of the gallery in geologically recent times, though we admit that the species referred to are ancient and probably existed at the epoch called post-glacial.

FIG. 18 (actual size).—Specimen of Layer 2. An acorn cup of the pin oak, *Quercus palustris*, and a gnawed mocker nut, *Hicoria alba*, rest upon fragments of cave clay and a mass of dry rat manure.

In the very close neighborhood of the bones, as further identified by Mr. Stewardson Brown, we found fragments of the acorns of the red oak, *Quercus rubra* Linn. (Fig. 17 object 5), and of the white oak, *Quercus alba* Linn.; an acorn cup of the pin oak, *Quercus palustris* Duke (see Fig. 18); half of a nut gnawed by rodents of the thick-shelled, small-kerneled mocker nut, *Hicoria alba* Linn., Br., (see Fig. 18) several gnawed nuts of shellbark, *Hicoria ovata* Mill, Br., and the gnawed nut of the butter nut, *Juglans cinerea* Linn. With these lay several fragments of winged seeds of blue ash, *Fraxinus quadrangulata* Mich. (see Fig. 19 and Fig. 17 object 4); two seeds of the horn beam, *Fraxinus caroliniana* Walt.; a piece of bark of the chokecherry; a seed of the gum *Nyssa sylvatica;* two small twigs of dogwood, *Cornus alternifolia* Linn.; fourteen little fragments of sticks and leaves and several pieces of bark undetermined, together with two wild cherry stones, *Prunus pennsylvanica* Linn.; while recorded as exactly under one of the sloth bones we pulled out a seed of the alder, *Alnus incana* Linn. (see Fig. 20), and another of the horn beam, *Carpinus caroliniana* Walt., with a nut of the beech, *Fagus americana* Sweet (Fig. 19).

FIG. 19 (actual size).—Rat excrement, clay and vegetable rubbish characteristic of Layer 2. Against two fragments of the winged seeds of the blue ash, *Fraxinus quadrangulata*, and inside of a gnawed acorn of the red oak, *Quercus rubra*, rests a beech nut, *Fagus americana*. These bones were unearthed near the large bones and had probably been brought into the cave for food or nest building by the cave rat, *Neotoma magister*.

There was no reason for doubting that these objects had reached their position at or about the time of

the deposition of the sloth bones. Many of the nuts had been gnawed by cave rats (see Fig. 17 object 9), *Neotoma magister*, and the same agile pilfering animal, helped possibly by the porcupine, had doubtless dragged in by way of the roof holes, whether for nest building, for food, or in pursuance of its eccentric hoarding habits, many of the other objects scattered at various points in Layer 2. In this mass of excrements of the cave rat, which, dry as they were, were crushed with some difficulty between the thumb and finger, together with the lesser porcupine coprolites, we found a hair from the back of the porcupine and a portion of the right side of the upper jaw with molar teeth of the cave rat (see Fig. 17 objects 16 and 15). Scattered irregularly through the layer, as identified by Mr. Thomas Meehan and Mr. Brown, lay an acorn cup of the Spanish oak, *Quercus digitata* (Marsh) Sud. (see Fig. 20); two fragments of acorns of the pin oak, *Quercus palustris;* a seed of the horn beam, *Carpinus caroliniana* Walt.; and fragments of seed of the blue ash, *Fraxinus quadrangulata* Mx.; a fragment of hickory nut, *Hicoria minima;* of hazel nut, *Corylus americana*, Walt. (see Fig. 17 object 18), and of beech nut, *Fagus americana* Sweet (see Fig. 19); a valve of the hop horn beam, *Ostrya virginica* Willd.; an awn of wild rye or lyme grass, *Elymus* Linn.; and a piece of the stipe of common brake, probably *Pteris aquelina* Linn. With these were two seeds of the blue ash, *Fraxinus quadrangulata*, others of the horn beam, *Carpinus caroliniana* (see Fig. 21), alder, *Alnus incana* (see Fig. 20), beech, *Fagus americana*, and gum, *Nyssa sylvatica* (see Fig. 21), two wild cherry stones. *Prunus pennsylvanicus*, a piece of chokecherry bark, twigs of dog wood, *Cornus alternifolia*, fragments of sticks (see Fig. 17 object 10) and leaves, and, according to Prof.

FIG. 20 (actual size).—Characteristic portion of the rubbish of Layer 2. Coprolites of the cave rat and pieces of dry clay form the background. The vegetable remains carried into the cave by rats and porcupines were found buried in the undisturbed layer near the sloth bones. 1. Acorn cup of Spanish oak, *Quercus digitata*. 3. Two seeds of the alder, *Alnus incana*, and, 2. Seed of the sunflower, *Helianthus annuus*, a plant supposed by botanists to have been transplanted by Indians from South America or the trans-Mississippi plains. Omitted from the evidence for reasons given below.

Heilprin, one of the bead-like stem segments of a crinoid characteristic of the carboniferous limestone of the cave walls.

Judged by this botanical association, the age of the sloth remains was that of the flora of the surrounding hills, and that had not changed since seeds, nuts and bones came together. These specimens of well-known trees and plants common to the forest of eastern North America still flourished upon the mountain above us.

But over and above the general significance of this fact, two objects discovered—the *fur* and the *large coprolite* had a particular bearing upon the investigation.[1]

FIG. 21 (actual size).—Objects which were imbedded in the cave earth about the time that the sloth bones reached their position. 1. Gnawed seed of the gum *Nyssa sylvatica*, and 2, gnawed seeds of the hornbeam, *Carpinus caroliniana*, found in the unhardened later part of the manure (Layer 2) around the resting place of the sloth. Cave rat coprolites and characteristic ingredients of Layer 2 in the background.

FIG. 22 (actual size).—Objects which reached their position in the cave earth before the advent of the sloth bones. 1. Jaw and bone of the bat, *Vespertilio gryphus*. 3. Hair of the cave rat, *Neotoma magister*, and 2. Skein of maize silk, *Zea mais*, excluded from the evidence for reasons given in the footnote.

1 Not in the underground darkness, but seven months later, during the examination of the contents of two muslin bags, brought from the cave, labeled Layers 2 and 3, and finally placed in glass jars, I found (as identified by Mr. Brown) two fragments of maize silk, *Zea mais*, (see Fig. 17 object 11, and Fig. 22 object 2), and a seed of the sunflower, *Helianthus annuus*, (see Fig. 20 object 2). If unquestionably bedded as deeply in the undisturbed deposit as the sloth bones, these specimens might well have testified to the existence of an aboriginal cornfield or sunflower plantation rifled by cave rats on the hill above, or in other words (if with recent investigators we suppose maize to have been indigenous to southern Mexico, the sunflower to South America or the trans-Mississippi plains, and disseminated North and East by Indians), to the contemporaneity of the red man with the sloth. But as several ears of corn in the husk came from Tennessee in contact with the specimen bags, there is a chance that skeins of the former, clinging to the outside of the muslin bags may have fallen into the glass jars, when the latter were filled from the bags—while a mischance in the process of affix-

FIG. 23 (actual size).—Mass of felted hair of rodents, together with a fine wool belonging possibly to the extinct sloth, found scattered through Layer 2, and often near the large bones. On this lies a jaw from the same layer of the bat, *Adelonycteris fusca*. The background shows the mass of rat manure and clay fragments characteristic of Layer 2.

Sometimes close to the bones, and generally scattered through the whole mass of manure in Layer 2, felted like tufts of carpet dust in an unswept room, lay wads of hair or fur (see Fig. 23, Fig. 5 object 4 and Fig. 17 object 14), exceedingly fine, slightly crinkled, with a reddish brown color, possibly due to contact with the cave earth. To what animal shall we attribute them? Certain fine bits may, according to Mr. Rhoads, be referred to the bat and a few straight hairs to the rat or porcupine. But as none of the rat fur has this crinkle, and as the under fur of the porcupine, according to Mr. Rhoads, is coarser than these specimens and always straight, this crinkled cave wool is attributable to neither animal. Shall we suppose it to be the under fur of the buffalo, or of any of the animals of the outer forest carried down into the cave in predominant quantity by rats? Is it sloth fur, and if so, why its extreme fineness? Where are the large, limp hairs, flattened in appearance and grayish white in color, characteristic of the living sloths? Shall we fancy the fossil sloth fine-furred as a seal? Yet if this discovered fur, which in all reason is contemporary with the sloth bones, be not sloth fur, what became of the sloth fur if the animal, as we suppose, perished here?

Leaving the significance of the fur in doubt, we are left to account for the comparatively large excrement of a herbiverous animal, likewise found in Layer 2, and altogether too large for the porcupine or cave rat (see Fig. 17 object 8 and Fig. 5 object 3). Because no other trace of a herbiverous animal of the size indicated was observed at the spot, and because of the herbiverous character of the sloth itself, it has seemed to Mr. Rhoads and myself possible to refer it, modern as it looks, to the latter mammal rather than to

ing labels makes it doubtful whether the sunflower seed belongs to Layer 2, or came from a rat-hole. For these reasons, I abandon the hope of positive demonstration involved in the presence of the sunflower (used by Indians for food and oil, and of maize, his favorite plant), that sloth and Indian were contemporaries at Big Bone cave.

the exceptional presence of any other grass-eating creature at that part of the cave. On the other hand, it appears small for the great sloth, while its unbroken contours infer that it must have been transported when dry and hard if we are to ascribe it to the deer or any animal of the outer forest, and suppose that the hoarding rat carried it down the roof holes into the cave.

In the compact lower portion of the manure called Layer 3, forming, as before described, a crust suggestive of an older floor immediately under the bones, we found what by a reasonable inference were regarded as

Objects Older Than the Bones.

Here in the dense mass of rat excrement, rested a lower jaw of the bat, *Adelonycteris fusca* (see Fig. 25 object 7), as to which, in completing the list of bat remains found in the cave, Dr. Allen says that the bats here described seem larger than our common eastern forms, though no marked variation in bats has been observed since the Pleistocene.[1] Not far from this, and as kindly identified by Mr. C. M. Johnson, of the Wagner Institute, lay a well-preserved dry carcass of the small "window" fly (see Fig. 24), common in the United States, first described in America by Say, in 1828, as a new species, *Scenopinus pallipes*, but afterwards recognized as identical with the European *Scenopinus fenestrartis* Linn., the window-haunting adult insect of the so-called carpet worm. Entomologists have left us in doubt as to its life and habits, but we may suppose that its food quest led it so far under ground as a consumer either of decayed wood, of dried wooly or animal matter (like carpets under which its thin larvæ are often found), or according to Willaston, of the minute *tinidæ*, or the true wool-devouring moths, *psocidæ*, who would have attended the decomposition of animal skins and furs at the spot. However the fly's visit to the subterranean darkness is to be accounted for, there can be little doubt that it came down through the roof holes like the cricket above mentioned,

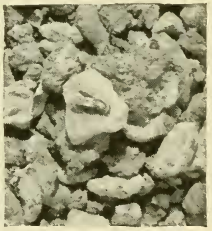

Fig. 24 (actual size). —Dry carcass of the window fly, *Scenopinus fenestralis* Linn., embedded in the cave earth before the sloth bones reached their position.

[1] Of the few fossil bats found in America, Lund discovered four species of *Vampyrus*, one species of *Molossus* and one species of *Peropteryx* in Pleistocene

while its position at this depth in the cave refuse would testify to its presence in America before the coming of Columbus, were entomologists not sufficiently sure that it had not followed the white discoverers in their ships across the Atlantic.

Near by were found bedded in Layer 3 small pieces of bark, nuts, grass, twigs, and plant fibre unidentified, pieces of horn beam seed, *Carpinus caroliniana* (see Fig. 25 object 5); a seed of the blue ash, *Fraxinus quadrangulata;* two shellbarks, *Hicoria ovata*, and four fragments well gnawed by rodents; a gnawed bitternut, *Hicoria minima*, showing orifices for extracting the kernel made by a small rodent; and six pieces of the acorn of the pin oak, *Quercus palustris* (for all of which see Fig. 25). Judging by the absence

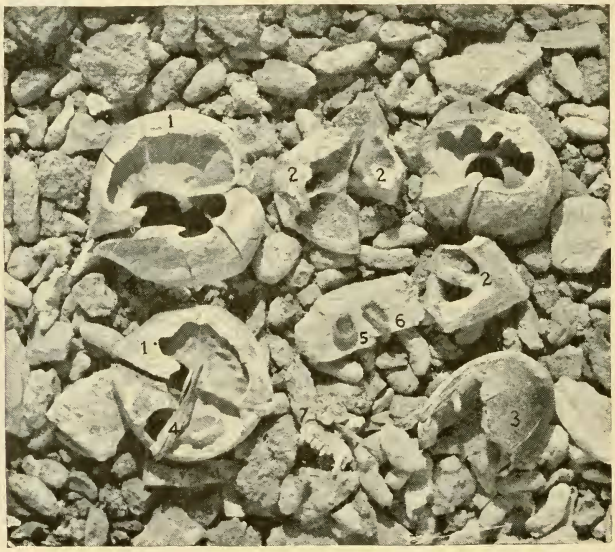

FIG. 25 (actual size).—Objects which reached their position in the cave earth before the advent of the sloth bones. 1. Shellbarks, *Hicoria ovata.* 2. Bitternut, *Hicoria minima*, gnawed by rodents. 3. Acorn of pin oak, *Quercus palustris.* 4. Fragment of seed of blue ash, *Fraxinus quadrangulata.* 5 and 6. Nut and seed of the hornbeam, *Carpinus caroliniana.* 7. Lower jaw and bone of the bat, *Adelonycteris fusca.* The background consists of the characteristic ingredients of Layer 3.

Brazilian caves; and Marsh gives two species of *Nyctetestes* and one of *Nyctetherium* from the Eocene of the United States (see *Catal. de Mamiferes*, Tronsaert, Paris, 1879, extr. *Rev. et Mag. de Zool.*, 1878).

of quills, hairs and coprolites, the porcupine had not visited the cave during the formation of Layer 3. Neither were we able to find in the latter layer the wads of fine fur so characteristic of Layer 2 above it, but if these were specimens of sloth fur, their absence is what we might have expected since the fur of the sloth could not well have been scattered over a lower depth than the resting place of its carcass. The absence of these ingredients, these differences in character, together with its position, were sufficient to assign an older date to the lower layer, whether its crusted consistency was due to the infiltration of animal matter or not. According to the order of formation of the different refuse, the lower layer preceded the upper, and the gnawed nuts, the seeds, the fly preserving intact its delicate wings, comparatively modern as they seemed, had reached their position before the deposition of the bones.

Faint from continual inhalation of the noxious dust, we had lost the energy to excavate to its bottom, the last and lowest layer,

LAYER 4,

(*Depth unknown.*)

a mass of fine water-laid clay, broken in lumps ranging in size from six inches to a quarter of an inch in diameter (see Fig. 26), covering the whole floor of the gallery and evidently the equivalent of the nitrous earth which had been elsewhere removed. By their laminated structure the lumps gave evidence of their aqueous deposition, while hard as they now were they dissolved immediately on immersion in water. Some pieces showed an irregular texture as of the caking together of various partially hardened muds, while others, in the opinion of Mr. George Vaux, Jr., revealed small fragments (irreducible by boiling in water), of adulterated carbonate of lime, probably aragonite. After digging several holes in the mass to learn that the manure had infiltrated downwards for at least two feet through

FIG. 26 (actual size).—Characteristic specimens (of Layer 4) under the sloth bones. Photograph of angular fragments of dry cave clay, "petre dirt," between which rat coprolites are seen. The fragments grew larger and were less mixed with manure as the excavation went deeper, but the bottom of this lowermost layer was not reached.

its interstices, we abandoned it where the configuration of the cave walls, widening as we went down into a crevice of unknown depth (see Fig. 4), rendered further work under the circumstances hopeless. We left with the reasonable inference that a depth of five, ten or fifteen feet would have laid bare the whole bottom, as it had been laid bare elsewhere in the gallery. Doubtless the process of drying, which succeeded the deposition of the layer by water, had broken it into lumps, between which the upper refuse, as remarked before, had penetrated, thus adulterating it without obscuring the fact that in its true constitution, for the eighteen inches examined, it contained no trace of man or animals.

Allowing the dust to settle for the last time, we turned away from the mysterious spot, and, threading our way wearily through the chilly gallery, came with sudden shock upon the dazzling glow and severe heat of a southern evening. With difficulty we toiled homeward, resting often in the warm woods.

At the last remaining point of significance we had examined layers which probably present all the evidence that will ever be collected as to the antiquity of the fossil sloth of Big Bone cave.

Let paleontology enlighten us as to the probable character and habits of this animal which we must reasonably regard as one of the common inhabitants of the American forest in Pleistocene times. Comparing the large vertebræ, the skull, the proportionately shorter claws and stouter limbs with the skeletons of the existing South American sloths, as here shown (thanks to the kindness of Dr. H. C. Chapman), we may well disbelieve that this animal hung, like the latter, back downward for days upon a single bough, or lagged in one tree or grove until moss formed upon its fur. How shall we imagine the creature, weighing from twelve to sixteen hundred pounds, moving from tree top to tree top in any known North American forest, when on the blowing of wind, according to the saying in Brazil, sloths travel. On the contrary, as the continual falling of so large an animal by the breaking of boughs is not to be imagined, we must deny the creature a strictly arboreal life, rather supposing, with Prof. Cope, that the boughs came down to the sloth than that the sloth went up to the boughs. In place of moss-covered clumps of motionless fur not easily distinguished from leaves, that a keen eye recognizes in South American tree tops, we fancy animals inhabiting the earth and proclaiming their presence by the crash of saplings and outlying boughs.

as, rising upon their hind legs or climbing to the forks of heavy trunks, they tear their fodder to the ground.

If they despised water, like the Ai and Unau, they licked salt, as their fossil bones bedded in the Petit Anse salt pit in Louisiana and the mire of Big Bone Lick testify. As terrestrial animals continually on the defensive against the foes of the forest, probably little less active than bears, the great sloths would hardly have rolled helplessly upon their backs when attacked like the Unau, or yielded up their dinner with a melancholy drone. On the contrary, though we must imagine them inoffensive and by no means agressive enemies of animals or man, the thrust of the powerful arm, and scratch with the claws that brought down saplings, might well have defended them against powerful and active foes.

A categorical demonstration that this individual animal was a contemporary of the geologically recent Indian in Tennessee must be abandoned. But the reasonable inference of such association remains. Though the human handiwork, in the form of charcoal and torch refuse (except the rat-hole specimens), lay really on the surface (Layer 1), from six inches to one foot above any sloth bone found; we may justly be satisfied with the recent significance, broadly regarded, of the whole record, and with the absence of plants and smaller animals of any extinct or positively ancient form.

Gradually a thin sprinkling of rat excrement upon the clay floor had thickened into a dry dense mass. Before the deposit had reached a depth of two feet, the sloth had appeared and perished, and while the duration of this manure-making process, which finally, rising round the bones, covered them to a depth of one foot or eighteen inches, cannot be safely guessed at in terms of centuries, there can be no doubt that it is geologically recent, and that its construction which preceded and followed the deposition of the sloth bones is continued by the visits of existing cave rats at the present day. The manure formed, the leaves, nuts, grass and seeds found their way in, without the interruption of any important interval of time or geological event changing the topography of the cavern. The roof holes had probably remained open continuously. The subterranean temperature of fifty-five degrees Fahrenheit, with an extreme dryness, had probably persisted. The same flora had continued to flourish upon the mountain. The same visiting animals had continued to find the same plant food, while the same bat species had sailed in from the open entrance.

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Had these bones lain within reach of the percolating chloride of lime, this mineral filling the cavities vacated by animal matter might have hardened them as cave bones are often hardened, but lying where we found them we may well doubt whether they ever would have fossilized. Under such circumstances, let us believe that a nut, a seed, a leaf, or even a fly, would preserve the freshness of its structure for a long time, and hence that the interesting remains found with the bones may not be so modern as they seem. With this reservation, and without attempting to deal definitely with dates, it seems safe to class the evidence not only as geologically but as historically recent. Not more ancient in appearance, not more brittle than the bones of animals found by me in the Indian midden-heaps of several caves, the position of the bones in the upper and later part of the rubbish, their gnawed condition, and their association, as described above, offer nowhere a suggestion of great antiquity. Separated from all association with the remains of other Pleistocene animals, they fail to lend the color of antiquity to the situation. On the contrary, like the peccary bones found at Durham cave,[1] like the remains of tapir and mylodon discovered in Lookout cavern,[2] they seem modernized by their surroundings. Let us infer that we have found a species which, long surviving its day and earlier relationship, had become an anomaly; that we have modernized the fossil sloth, if we have not definitely increased the antiquity of the Indian hunter, whose first coming the animal doubtless witnessed in the woods of Tennessee.

1 An exploration of Durham cave by H. C. Mercer, Publications of University of Pennsylvania, Vol. vi. Ginn & Co., Boston, 1897.

2 Bulletin distributed by the Department of American and Prehistoric Archæology at the University of Pennsylvania. January, 1894.